SURFACE WATER QUALITY

OF THE NIAGARA RIVER

1980 - 1982

by

Lorraine E. Post,
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Great Lakes Section
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FOREWORD

The Ministry of the Environments' investigation of water quality conditions related to trace contaminants in the Niagara River during 1980-1982, formed part of Ontario's contribution to the Niagara River Toxics Committee Report (1984).

Recommendations for remedial action based on this data and other studies are contained in the NRTC Report.

This data, as well as conventional water quality parameters not included in the Toxics Committee Report are presented here.

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ACKNOWLEDGEMENTS

The authors gratefully acknowledge the efforts of field personnel in the collection of samples and the efforts of the Water Quality, Microbiology, Inorganic Trace Contaminants and Pesticides Laboratory Sections in the analysis of these samples.

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SUMMARY

During the years 1980 to 1982, the Ontario Ministry of the Environment's Water Resources Branch conducted intensive surveillance and monitoring programs of the Niagara River to increase the understanding of the complex international water quality problems associated with persistent toxic substances and to assist the Niagara River Toxics Committee in its deliberations. Conventional parameters were monitored in conjunction with trace contaminants to identify areas where surface Water Quality Objectives were not being met.

This report summarizes water quality data for three years (1980-1982) of the intensive surface water monitoring of the Niagara River. Summary data is presented for all sampling locations; however, comparisons between the years are restricted to four common locations; the headrange, the downstream end of the Tonawanda Channel, the downstream end of the Chippawa Channel and the lower river.

Samples were analyzed for major ions, nutrients, bacteria, phenolics, metals, PCBs and other trace organics. In addition, an expanded list of priority organic compounds were investigated in 1982.

Yearly mean concentrations of nutrients and the physical parameters measured were relatively consistent along the river's length; however some cross-channel gradients in nutrient levels were observed, primarily at the Buffalo River mouth and along the Tonawanda Channel. These areas of nutrient enrichment are related to waste discharges from areas of urban and industrial development.

Bacterial densities in excess of Provincial Water Quality Objectives were observed in the Buffalo River mouth and along the mainland shore of the Tonawanda Channel in all of the survey years.

A substantial reduction in the levels of total phenolics was noted from 1971, when up to 100% of the samples from the Niagara River exceeded the PWQO (1 ug/L). Levels from 1980-1982 exceeded the PWQO in 0-34% of the samples taken at locations along the river.

Over the three year period from 1980 to 1982, levels of copper, iron and silver were frequently found in excess of the Objectives. Arsenic, cyanide, chromium, lead and nickel were never detected at levels exceeding the Objectives.

Analyses for PCBs and organochlorine pesticides during 1980, 1981 and 1982 indicated that the majority of samples contained concentrations below the Water Quality Objectives. PCBs exceeded the Objective, in the Upper Niagara River only, in less than 10% of the samples from the Tonawanda and Chippawa Channels and at the headrange.

Levels of γ-BHC, heptachlor epoxide, endrin and dieldrin occasionally (<10%) exceeded Provincial Water Quality Objectives, primarily in the Tonawanda Channel, although detections of organochlorine compounds were observed throughout the river. Of the fifty-two additional compounds analyzed for in 1982, only six were identified in Niagara River water, with concentration ranges just above the analytical detection limits.

I INTRODUCTION

Historically, pollution concerns in the Niagara River have centered around conventional problems such as bacterial contamination, the presence of phenols and oil slicks, and aesthetic impairment in the form of odours and discolouration (IJC, 1951, 1967).

As early as 1913, surveys indicated that the Tonawanda Channel, portions of the Chippawa Channel and the entire river below the Falls were bacterially (E. coli) contaminated as a result of the discharge of raw sewage (IJC, 1914).

Waste reduction programs in the form of controls on discharges to the river have helped to alleviate the impact that these conventional pollutants have had on the river. However, there are some areas where conventional water quality parameters fail to meet surface Water Quality Objectives (Ontario Ministry of the Environment, 1984). More recently, the focus of concern for the Niagara river has shifted to the presence of persistent toxic substances, the discovery of numerous abandoned or leaking waste disposal sites in the drainage area, and the impact of existing and proposed municipal and industrial discharges to the river (COA 1980, 1981; IJC 1981; NRTC, 1984).

During the years 1980 to 1982, the Ontario Ministry of the Environment (MOE) conducted intensive surveillance and monitoring programs of the Niagara River to increase the understanding of the complex international water quality problems associated with persistent toxic substances and to assist the Niagara River Toxics Committee in its deliberations. Conventional parameters were monitored in conjunction with trace contaminants to identify areas where surface Water Quality Objectives were not being met.

This report summarizes water quality data for three years (1980 - 1982) of the intensive surface monitoring of the Niagara River. A more detailed analysis of inorganic and organic trace contaminants for the study period appears in the Niagara River Toxics Committee Report (NRTC, 1984). Previous years' data can be found in "Environmental Baseline Report of the Niagara River", Canada-Ontario Review Board, (1980). Recent monitoring data collected at Niagara-on-the-Lake and Fort Erie is contained in "Joint Evaluation of Upstream/Downstream Niagara River Monitoring Data 1984-1986" prepared by the Data Interpretation Group of the Toxics Management Plan for the Niagara River (1986).

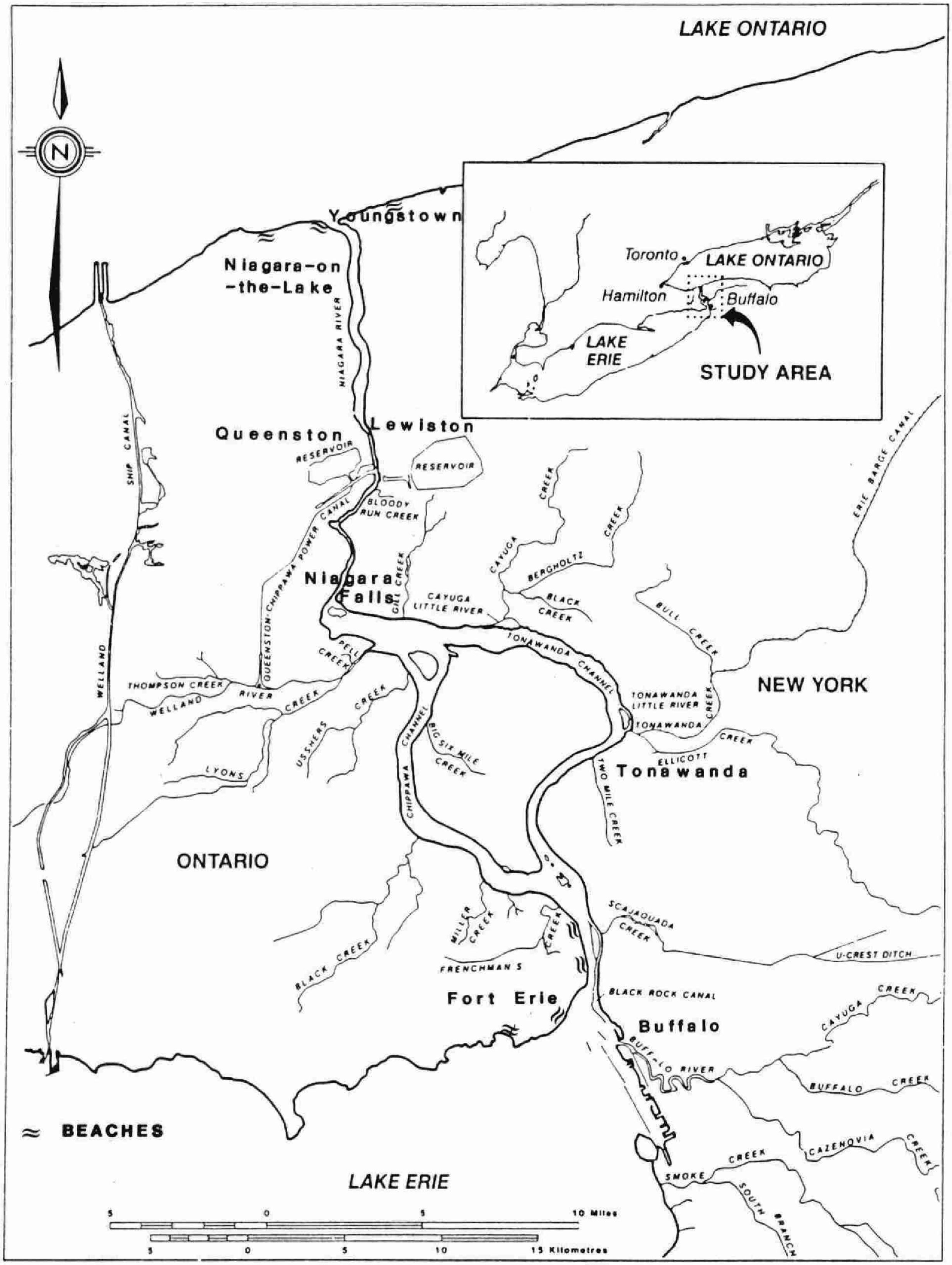

FIGURE 1. Study Area

II DESCRIPTION OF THE NIAGARA RIVER BASIN

The Niagara River is a 58 km (37 mile) waterway connecting the eastern basin of Lake Erie with the western basin of Lake Ontario (Figure 1). The river flows in a northerly direction at an average rate of 5,700 cubic metres per second (200,000 cubic feet per second) with little seasonal or year-to-year variability. However, strong south-westerly winds or seiches in Lake Erie can cause periodic and sudden variations in the water levels and the flow (IJC, 1951; Hamblin, 1979).

The Niagara River drains an area of 227,000 square kilometres (88,000 square miles) and provides approximately 83% of the tributary inflow and 50% of the total sediment load to Lake Ontario (NRTC, 1984). The Niagara River, at Lake Erie, begins with a funnel-shaped entrance, rapidly constricting to a narrow, shallow, swiftly flowing channel. Navigation past this point is possible through the Black Rock Canal, which parallels the river for 5.5 km (3.5 miles) on the American side. Past the canal exit, the river divides into two channels around Strawberry and Grand Island: the east Tonawanda Channel and the west Chippawa Channel. The Chippawa Channel is approximately 18 kilometres long (11 miles) and carries 58% of the total river flow. The international border follows the Chippawa Channel. The Tonawanda Channel carries the remaining river flow (42%) along its 24-km (15-mile) length.

The majority of urban and industrial development on the river is located on the New York State side, in the cities of Buffalo, North Tonawanda and Niagara Falls; whereas parkland with inland agriculture predominates along the Ontario side. The Chippawa and Tonawanda Channels converge at the north end of Grand Island to form the Chippawa-Grass Island Pool. Waters from both Channels which are not diverted for hydroelectric uses are thoroughly mixed after passing over the Falls.

The height of Niagara Falls is approximately 56 metres (182 feet). From this point, the river drops an additional 23 metres (75 feet) through a 5 kilometre (3 mile) section of the Lower River known as the Whirlpool and Whirlpool Rapids. The remaining 11 kilometres (6 miles) portion of the lower river is relatively calm.

The major tributaries flowing into the Niagara River from the American shore are the Buffalo River, Ellicott Creek and Tonawanda Creek. The Buffalo River flows in a northwesterly direction through a heavily populated and industrialized area, discharging at the source of the Niagara River. Flows in the lower reaches of Tonawanda Creek are reversed in direction during the navigation season (April/May to November/December) when it serves as a portion of the New York State Barge Canal. Two other smaller tributaries draining the U.S. shoreline are Scajaguada Creek and Cayuga Creek.

The Welland River is the principal Canadian tributary to the Niagara River. However, its eastern section is used as a diversion channel to direct Chippawa Channel water to the Queenston-Chippawa Power Canal. A number of smaller tributaries also drain from the Canadian and American shores mainly into the upper Niagara River (Figure 1).

The major direct discharger of effluent into the lower river is the Niagara Falls, New York wastewater treatment plant. The Niagara Falls, Ontario water pollution control plant discharges into the Queenston-Chippawa Power Canal which in turn also discharges to the lower river. The Power Authority of the State of New York and Ontario Hydro power plant tailraces which draw water from the upper river also discharge to the lower river. The power plant tailrace discharges also provide additional mixing of the river water.

III USES OF THE RIVER

The Niagara River is heavily utilized for a variety of purposes including domestic and industrial water supplies, waste assimilation, recreation (swimming, boating and fishing), commercial navigation and hydro-electric power generation. Tourism is also a major industry in the Niagara Region due to the majestic splendour of Niagara Falls.

The Niagara River is also a source of drinking water for more than 400,000 people in both Canada and the U.S. In return, the river receives municipal and industrial wastes from populations on both sides of the border. Twelve municipal wastewater treatment plants and 89 industrial facilities are licensed by New York State to discharge their waste directly to the river. An additional 300 industries discharge indirectly via the wastewater treatment plants (COA, 1981). Ontario industrial and municipal discharges (12 and 3 respectively) are located primarily in the Fort Erie and Welland-Niagara Falls areas. The total effluent flow from U.S. point sources to the River (1499×10^3 m^3 day^{-1}) is over six times the volume from Canadian sources (236×10^3 m^3 day^{-1}) (IJC, 1979).

Over 215 American waste disposal sites have been identified in Erie and Niagara Counties of which 164 are within 3 miles of the Niagara River. Twelve sites were identified on the Canadian side (COA, 1981, NRTC, 1984). Evidence exists that, of the 164 American sites identified, 61 have significant potential to contaminate the river, of which 29 have contributed or are contributing contaminants to the Niagara River (NRTC, 1984).

The reader is referred to the Niagara River Toxics Committee Report (NRTC, 1984) for detailed descriptions and locations of industrial and municipal intakes, outfalls, and waste disposal sites.

IV SURVEY OUTLINE AND METHODS

From 1980 to 1982, the Ontario Ministry of the Environment conducted intensive surveys of water quality in the upper and lower reaches of the Niagara River. Water samples were obtained at a depth of 1.5 m from discrete stations along river ranges (transects) identified in Figure 2. Transects are identified by "NI" to designate the Niagara River, and a number representing distance in river miles upstream from the zero mileage point (a bell buoy located 1 mile from the mouth of the Niagara River in Lake Ontario). The number of stations sampled along each range are indicated on Table 1. In 1982, additional stations, located in the nearshore, in the vicinity of suspected source areas, were also sampled. These are identified by discrete station numbers and not range numbers in Figure 1.

Samples were analyzed at the Ontario Ministry of the Environment's Toronto Laboratory for major ions, nutrients, bacteria, phenolics, metals, PCBs and other trace organics. Table 1 summarizes the locations and parameters analyzed for each survey year. Field measurements of dissolved oxygen, temperature, pH and secchi disc depth were also obtained. Table 2 lists priority organic compounds (in addition to PCBs and organochlorine pesticides) which were investigated in 1982.

Field methodologies are described in "A Guide to the Collection and Submission of Samples for Laboratory Analysis" (MOE, 1979). All chemical and bacteriological analyses were performed according to the "Handbook of Analytical Methods for Environmental Samples" (MOE, 1980, 1981).

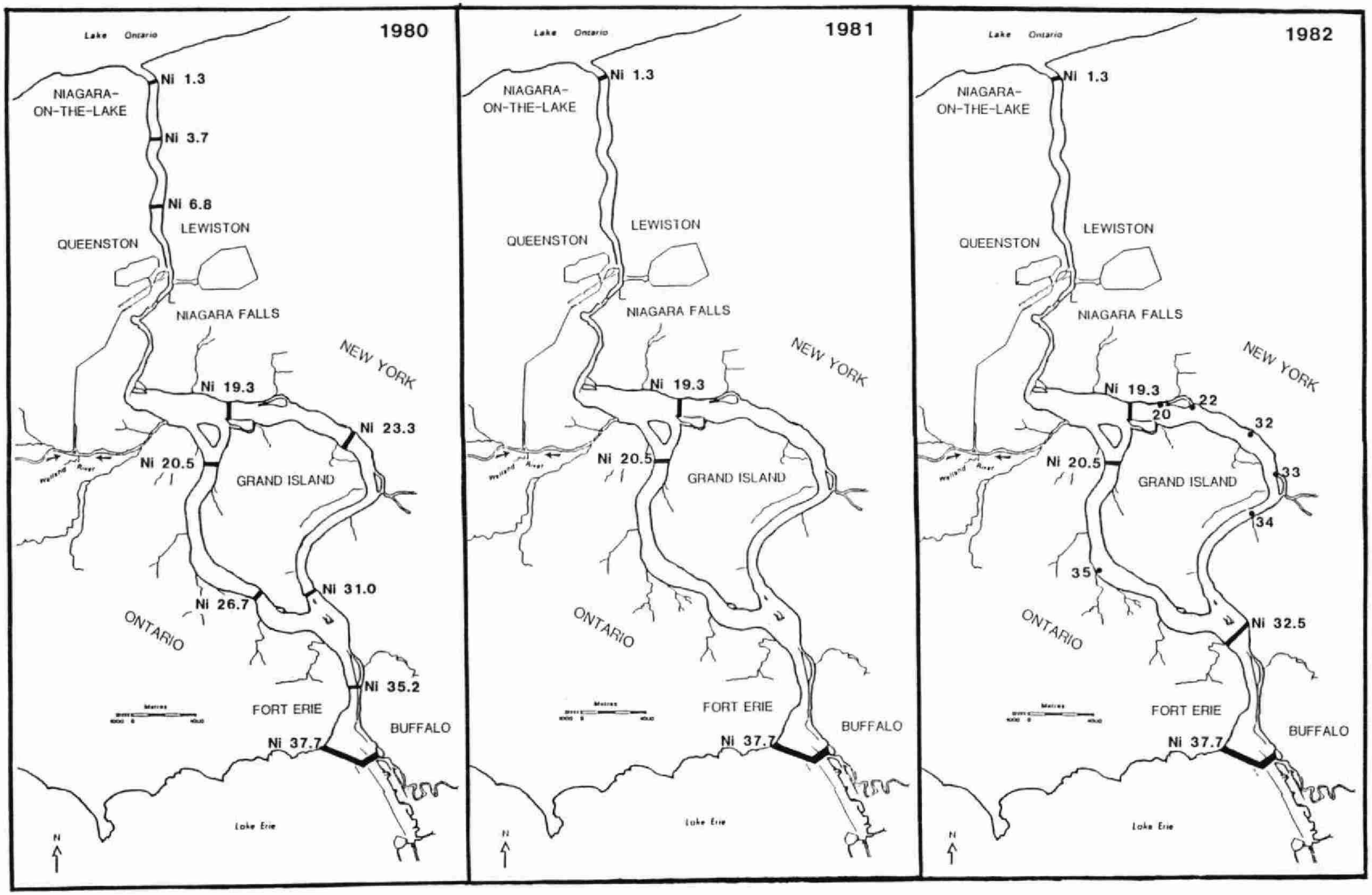

Figure 2. Niagara River water quality monitoring locations (ranges) during 1980, 1981 and 1982 survey years.

TABLE 1

Parameter List for Niagara River surface water quality, 1980-1982

	1980										1981				1982										
	37.7	35.2	26.7	20.5	31.0	23.3	19.3	6.8	3.7	1.3	37.7	20.5	19.3	1.3	37.7	32.5	19.3	20.5	20	22	32	33	34	35	1.3
	(6)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(6)	(5)	(5)	(5)	(9)	(5)	(6)	(5)							(5)
Conventionals																									
water temperature	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
dissolved oxygen	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
pH	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Secchi depth	*	*	*	*	*	*	*	*	*	*	*	*	*	*											
conductivity	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
turbidity	*	*		*	*		*																		
chloride	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
sulphate	*	*	*	*	*	*	*	*	*	*	*	*	*	*											
phenols	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
total phosphorus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
total Kjeldahl nitrogen	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
filtered ammonia	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
nitrites + nitrates	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
suspended solids															*	*	*	*	*	*	*	*	*	*	*
Bacteria																									
total coliforms	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
fecal coliforms	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
fecal Streptococcus	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Pseudomonas aeruginosa	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
heterotrophic bacteria	*	*	*	*	*	*	*	*	*	*	*	*	*	*											
Inorganics																									
aluminium				*			*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
arsenic				*			*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
cadmium				*			*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
chromium				*			*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
copper				*			*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
cyanide (available)				*			*			*	*	*	*	*											
iron				*			*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
lead				*			*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
mercury (unfiltered)											*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
silver															*	*	*	*	*	*	*	*	*	*	*
mercury (filtered)				*			*			*	*	*	*	*											
nickel				*			*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
zinc				*			*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
selenium															*	*	*	*	*	*	*	*	*	*	*

NOTE: ( ) indicates number of stations on range transect.

TABLE 1 cont'd

	1980										1981				1982										
	37.7 (6)	35.2 (5)	26.7 (5)	20.5 (5)	31.0 (5)	23.3 (5)	19.3 (5)	6.8 (5)	3.7 (5)	1.3 (5)	37.7 (6)	20.5 (5)	19.3 (5)	1.3 (5)	37.7 (9)	32.5 (5)	19.3 (6)	20.5 (5)	20	22	32	33	34	35	1.3 (5)
PCBs and Trace Organics																									
PCBs			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
aldrin/dieldrin			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
α-BHC			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
α,γ,Chlordane			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
DDT isomers+metabolites			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulphan I & II			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endosulphan sulphate			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Endrin			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
HCB			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Heptachlor			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Heptachlor epoxide			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mirex			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Methoxychlor											*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Oxychlordane											*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
β-BHC			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
γ-BHC			*			*				*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Table 2
Additional organic compounds investigated in the Niagara River, 1982

	# of Samples	# of Detections	Range (ug/L)
benzene	61	-	
toluene	61	7	1 - 3
ethyl-Benzene	60	1	1
p-xylene	60	-	
m-xylene	60	-	
o-xylene	60	-	
n-nitrosodimethylamine	42	-	
n-nitrosodipropylamine	18	-	
1,1-dichloroethylene	61	-	
dichloromethane	61	4	11 - 60
1,2-dichloroethylene	61	-	
dichloroethane	61	5	4 - 6
chloroform	61	-	
1,1,1-trichloroethylene	60	-	
1,2-dichloroethane	61	-	
carbon tetrachloride	61	-	
1,2-dichloropropane	61	5	2
trichloroethylene	61	-	
dichlorobromomethane	61	-	
1,1,2-trichloroethylene	61	1	1
chlorodibromomethane	61	-	
tetrachloroethylene	61	-	
bromoform	60	-	
1,1,2,2-tetrachloroethylene	60	-	
hexachloroethane	8	-	
bis (2-chl ethoxy) methane	8	-	
hexachlorobutadiene	7	-	
hexachloropentadiene	7	-	
chlorobenzene	54	-	
1,4-dichlorobenzene	54	-	
1,3-dichlorobenzene	54	-	
1,2-dichlorobenzene	54	-	
1,2,4-trichlorobenzene	8	-	
p-chloroanaline	7	-	
2-chloronaphthaline	3	-	
2-chlorophenol	2	-	
2,4-dichlorophenol	2	-	
p-chloro m-cresol	2	-	
2,4,6-trichlorophenol	2	-	
pentachlorophenol	2	-	
hexadecanoic acid	2	-	
naphthalene	45	-	
acenaphthylene	2	-	
phenol	2	-	
2,4-dimethylphenol	2	-	
butoxyethanol	7	-	
nitrobenzene	9	-	
dinitroltoluene	2	-	
2-nitrophenol	2	-	
2,4-dinitrophenol	2	-	
4-nitrophenol	2	-	
4,6-dinitro o-cresol	2	-	

V RESULTS AND DISCUSSION

As indicated in Table 1, locations of water samples and parameters analyzed varied with each survey year. Table 2 lists additional organic compounds investigated in 1982. While summary data are presented for all sampling locations, comparisons between the years are restricted to four common locations: NI 37.7 (the headrange); NI 19.3 (the downstream end of the Tonawanda Channel); NI 20.5 (the downstream end of the Chippawa Channel); and NI 1.3 (lower river).

Water quality discussed in this report is compared to the Provincial Surface Water Quality Objectives contained in the Ontario Ministry of the Environment publication "Water Management" (1984). These Objectives are for the protection of aquatic life, with the exception of bacterial Objectives which are for the protection of human health in relation to water-contact recreational activities.

A. Physical Parameters and Major Ions:

Data on dissolved oxygen, temperature, secchi disc depth, pH, turbidity, chloride and sulphate are contained in Tables 3 to 5. Yearly mean concentrations of these parameters were relatively consistent along the river's length.

B. Nutrients:

Mean concentrations of total phosphorus and nitrogen (total Kjeldahl, ammonia, nitrite + nitrate) for sampling locations during each survey year are contained in Tables 3 through 5. Little variation in yearly mean concentrations of total phosphorus was observed with increasing distance downstream or between comparable locations during the three survey years; however, some cross-channel gradients in nutrient levels were observed. A strong cross-channel phosphorus gradient is evident along NI 37.7 at the headrange of the Niagara River during 1980 and 1981, reflecting a high phosphorus input from the Buffalo River mouth and outer harbour areas (Figure 3). The impact of Buffalo Harbour on total phosphorus was not as pronounced in 1982. A strong gradient was also evident in the Tonawanda Channel (NI 19.3) phosphorus levels, reflecting the numerous inputs along the American shoreline. No consistent cross-channel gradients were evident for the Chippawa Channel (NI 20.5) or at the outlet of the lower river (NI 1.3).

TABLE 3

Mean concentrations of major ions and nutrients (mg/L except as noted) in Niagara River surface water, 1980

	NI 37.7	NI 26.7	NI 19.3	NI 23.3	NI 35.2	NI 20.5	NI 31.0	NI 6.8	NI 1.3	NI 3.7
chloride	19.5 ±0.3 (77)	19.1 ±0.05 (55)	19.4 ±0.1 (60)	20.1 ±0.3 (60)	19.6 ±0.3 (62)	19.0 ±0.05 (60)	19.9 ±0.3 (60)	19.7 ±0.1 (50)	19.6 ±0.1 (55)	19.6 ±0.1 (50)
sulphate	26.1 ±0.2 (65)	25.9 ±0.06 (45)	26.5 ±0.2 (50)	26.3 ±0.2 (50)	25.7 ±0.1 (55)	25.7 ±0.1 (50)	26.2 ±0.2 (50)	26.1 ±0.1 (60)	26.2 ±0.1 (60)	26.1 ±0.1 (59)
total phosphorus	0.021±0.002(78)	0.016±0.001(60)	0.029±0.003(60)	0.030±0.003(64)	0.020±0.002(65)	0.018±0.001(60)	0.022±0.002(65)	0.018±0.0005(60)	0.019±0.001(60)	0.020±0.001(60)
total k'dahl nit.	0.30 ±0.01 (78)	0.26 ±0.01 (60)	0.32 ±0.01 (60)	0.32 ±0.01 (64)	0.28 ±0.01 (65)	0.27 ±0.01 (60)	0.28 ±0.01 (65)	0.32 ±0.01 (60)	0.30 ±0.005(60)	0.31 ±0.01 (60)
filtered ammonia	0.028±0.003(78)	0.222±0.001(60)	0.039±0.003(60)	0.040±0.004(63)	0.022±0.002(65)	0.024±0.002(60)	0.026±0.002(64)	0.050±0.004(60)	0.036 ±0.001(60)	0.037±0.002(60)
nitrite & nitrate	0.208±0.009(78)	0.202±0.008(60)	0.224±0.010(60)	0.221±0.009(63)	0.199±0.007(65)	0.024±0.008(60)	0.210±0.009(64)	0.238±0.011(60)	0.224±0.009(60)	0.227±0.009(60)
conductivity (us/cm)	294 ±1 (78)	293±1 (60)	296±1 (60)	295±1 (65)	293±1 (65)	293±1 (60)	294±1 (65)	293±2 (60)	290±2 (60)	293±1 (60)
turbidity (ftu)	1.17 ±0.35 (6)	1.12 ±0.22 (5)	-	1.81 ±0.38 (5)	1.10 ±0.22 (5)	-	1.27±0.32 (5)	-	-	-
secchi depth m.	2.1 ±0.2 (47)	2.3 ±0.2 (30)	1.5 ±0.1 (46)	1.7 ±0.1 (40)	2.1 ±0.2 (36)	1.0 ±0.1 (50)	2.0 ±0.2 (39)	1.6 ±0.1 (44)	1.6 ±0.05 (56)	1.7 ±0.1 (45)
dissolved O_2	10.5 ±0.2 (50)	10.4 ±0.4 (40)	9.6 ±0.2 (40)	10.0 ±0.2 (45)	10.2 ±0.2 (43)	9.8 ±0.2 (38)	10.2 ±0.2 (45)	10.6 ±0.3 (57)	10.9 ±0.3 (63)	10.3 ±0.2 (56)
pH (-log H+)	7.91 ±0.07 (60)	8.04 ±0.02 (30)	8.13 ±0.06 (33)	8.05±0.04 (50)	7.96±0.04 (49)	8.12 ±0.01 (28)	8.09±0.05 (49)	7.94 ±0.04 (30)	8.03 ±0.07 (36)	7.99 ±0.04 (30)
water temp., °C	16.2 ±0.6 (74)	16.6 ±0.8 (59)	16.6 ±08 (59)	16.5 ±0.7 (65)	1.64±0.7 (63)	15.8 ±0.8 (55)	16.6 ±0.7 (65)	16.9 ±0.7 (60)	16.8 ±0.7 (67)	17.0 ±0.6 (60)

NOTE: Values are means ± standard error

( ) indicates number of samples

TABLE 4

Mean concentrations of major ions and nutrients (mg/L except as noted)
Niagara River surface water, 1981

	NI 37.7	NI 19.3	NI 20.5	NI 1.3
chloride	18.6 ± 0.2 (71)	18.7 ± 0.11 (60)	18.1 ± 0.1 (60)	18.6 ± 0.05 (55)
sulphate	25.1 ± 0.9 (69)	25.5 ± 0.3 (58)	24.5 ± 0.2 (60)	24.5 ± 0.3 (53)
total phosphorus	0.019 ± 0.003 (69)	0.025 ± 0.002 (52)	0.017 ± 0.001 (58)	0.022 ± 0.001 (43)
total K'dahl nit.	0.31 ± 0.02 (69)	0.32 ± 0.01 (52)	0.28 ± 0.01 (58)	0.32 ± 0.02 (43)
filtered ammonia	0.038 ± 0.007 (68)	0.040 ± 0.005 (52)	0.017 ± 0.002 (58)	0.038 ± 0.004 (43)
nitrite & nitrate	0.163 ± 0.027 (69)	0.211 ± 0.012 (52)	0.166 ± 0.010 (58)	0.184 ± 0.012 (43)
conductivity, us/cm	292 ± 4 (72)	294 ± 4 (60)	288 ± 4 (59)	293 ± 3 (60)
secchi depth, m.	2.4 ± 0.3 (69)	1.4 ± 0.2 (59)	2.2 ± 0.2 (59)	1.6 ± 0.2 (59)
dissolved oxygen	8.9 ± 0.1 (54)	8.8 ± 0.1 (45)	9.1 ± 0.2 (53)	10.4 ± 0.2 (54)
pH (-log H+)	8.40 ± 0.06 (50)	8.38 ± 0.04 (44)	8.44 ± 0.03 (53)	8.33 ± 0.08 (30)
water temp. °C	17.1 ± 0.6 (72)	17.3 ± 0.6 (60)	16.6 ± 0.6 (59)	16.7 ± 0.7 (60)

NOTE: Values are means ± standard error
( ) indicates number of samples

TABLE 5

Mean concentrations of major ions and nutrients and physical parameters (mg/L except as noted) in Niagara River surface waters, 1982.

	NI 37.7	NI 32.5	NI 20.5	NI 19.3	20	22
chloride	18.0 ±0.2 (107)	17.3 ±0.1 (60)	17.1 ±0.07 (59)	17.6 ±0.1 (72)	18.6 ±0.2 (12)	18.2 ±0.2 (12)
total phosphorus	0.015±0.0001(109)	0.015±0.001(59)	0.013±0.0005(60)	0.019±0.001(70)	0.029±0.004(12)	0.027±0.003(11)
total K'dahl nit.	0.30 ±0.01 (109)	0.28 ±0.01 (59)	0.26 ±0.002 (60)	0.31 ±0.01 (71)	0.39 ±0.02 (12)	0.37 ±0.02 (11)
filtered ammonia	0.027±0.0005(108)	0.018±0.002(59)	0.011±0.001 (60)	0.039±0.004(72)	0.074±0.011(12)	0.081±0.010(11)
nitrite & nitrate	0.195±0.008 (108)	0.192±0.009(59)	0.187±0.008 (60)	0.207± .009(72)	0.221±0.024(12)	0.232±0.020(11)
conductivity, us/cm	291 ±1 (107)	288 ±1 (60)	288 ±1 (59)	287 ±1 (72)	292 ±3 (12)	289 ±3 (12)
secchi depth, m	2.7 ±0.1 (108)	2.0 ±0.1 (59)	2.8 ±0.1 (57)	2.3 ±0.1 (63)	1.8 ±0.1 (12)	2.1 ±0.2 (9)
dissolved oxygen	9.8 ±0.2 (110)	10.1 ±0.2 (60)	10.2 ±0.2 (60)	10.2 ±0.2 (72)	9.7 ±0.5 (12)	10.2 ±0.5 (12)
pH (-log H+)	8.36 ±0.06 (74)	8.39 ±0.08 (40)	8.39 ±0.07 (40)	8.33 ±0.07 (48)	8.22 ±0.20 (8)	8.36 ±0.19 (8)
watertemp., °C	14.9 ±0.5 (110)	14.6 ±0.6 (60)	14.4 ±0.6 (60)	15.3 ±0.6 (72)	15.5 ±1.4 (12)	15.7 ±1.4 (12)
suspended solids	2.6 ±0.2 (108)	2.9 ±0.6 (60)	2.7 ±0.2 (59)	3.4 ±0.2 (72)	7.5 ±2.7 (12)	4.4 ±0.8 (12)

	32	33	34	35	NI 1.3
chloride	18.3 ±0.2 (11)	19.0 ±0.2 (12)	18.1 ±0.3 (12)	17.2 ±0.2 (11)	17.6 ±0.06 (59)
total phosphorus	0.034±0.007(11)	0.024±0.002(12)	0.024±0.002(12)	0.017±0.002(11)	0.019±0.006(57)
total K'dahl nit.	0.44 ±0.04 (11)	0.35 ±0.02 (12)	0.33 ±0.02 (12)	0.27 ±0.01 (11)	0.31 ±0.05 (57)
filtered ammonia	0.090±0.007(11)	0.067±0.003(12)	0.047±0.008(12)	0.014±0.002(11)	0.037±0.019(57)
nitrite & nitrate	0.228±0.022(11)	0.217±0.021(12)	0.220±0.022(12)	0.180±0.021(11)	0.207±0.070(57)
conductivity, us/cm	289 ±3 (11)	289 ±2 (12)	289 ±2 (12)	289 ±2 (11)	289 ±6 (59)
secchi depth, m	2.2 ±0.2 (10)	2.0 ±0.2 (12)	2.0 ±0.2 (12)	2.2 ±0.3 (10)	2.1 ±0.5 (56)
dissolved oxygen	10.2 ±0.6 (11)	10.2 ±0.6 (12)	10.2 ±0.6 (12)	9.8 ±0.4 (11)	10.4 ±1.9 (49)
pH (-log H+)	8.34 ±0.20 (7)	8.31 ±0.18 (12)	8.34 ±0.14 (12)	8.34 ±0.16 (8)	8.39 ±0.22 (40)
watertemp., °C	16.1 ±1.4 (11)	15.7 ±1.4 (12)	15.8 ±1.3 (12)	14.7 ±1.6 (11)	15.4 ±5.1 (54)
suspended solids	4.2 ±1.0 (11)	3.9 ±0.4 (12)	4.4 ±0.5 (12)	5.1 ±1.6 (11)	3.5 ±1.4 (58)

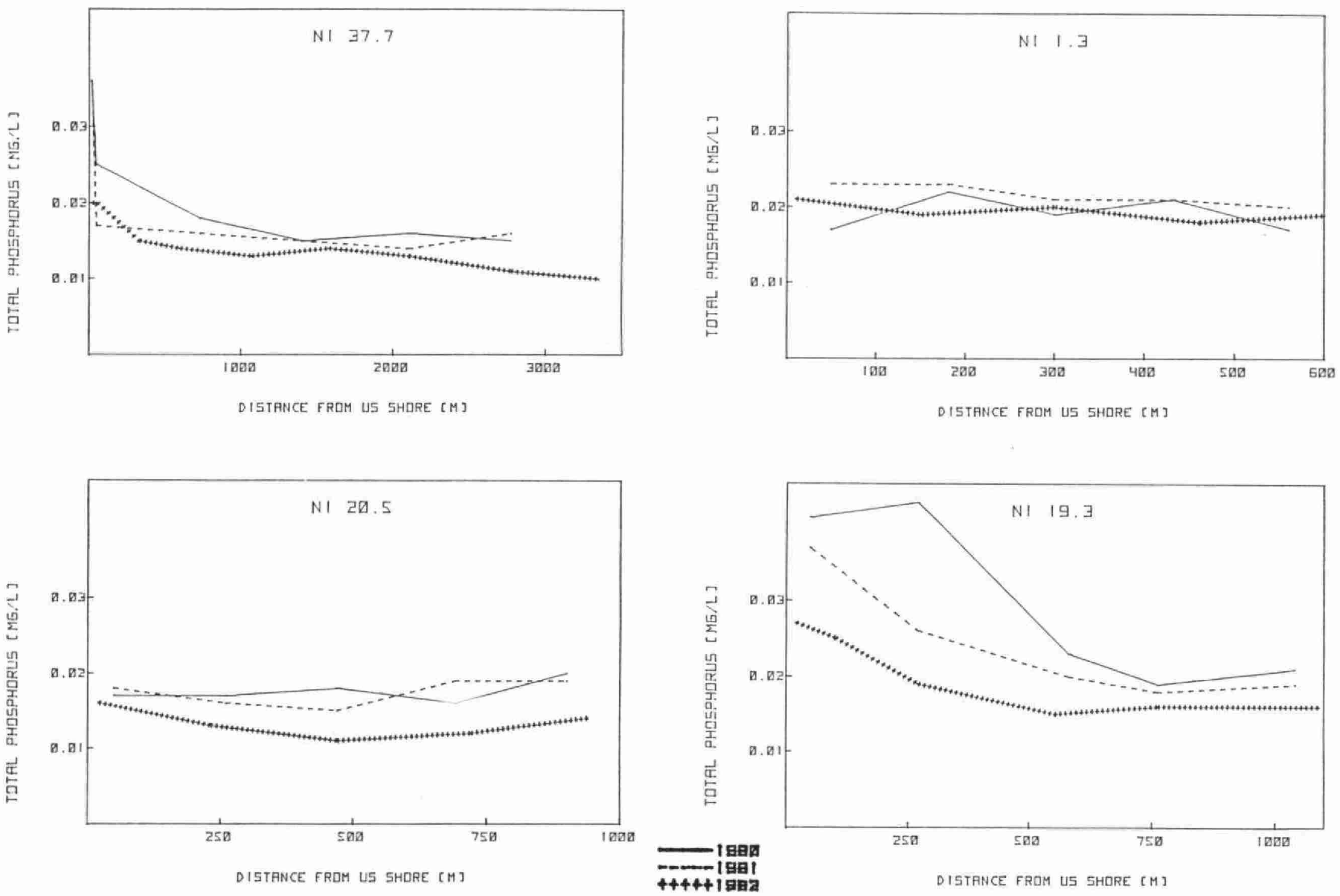

FIGURE 3: Total Phosphorus levels in the Niagara River, 1980-1982

Corrective action to address the problem of phosphorus inputs from combined sewer overflows in the Buffalo River was scheduled to begin in 1984. This remedial action should help to reduce phosphorus inputs to the Niagara River from this area.

Levels of total nitrogen, filtered ammonia, nitrite plus nitrate and total Kjeldahl nitrogen were also elevated at the Buffalo River mouth and along the mainland shore of Tonawanda Channel. As in the case with phosphorus, these areas of nutrient enrichment are related to waste discharges from areas of urban and industrial development.

C. **Microbiology**:

The waters of the Niagara River are used for a variety of recreational activities. Figure 1 shows the location of public bathing beaches in areas surrounding the Niagara River. Table 6 summarizes the 1980 to 1982 microbiological results for the Niagara River.

Microbiological contamination can endanger the health of those using the Niagara River for swimming, water skiing, and other water-contact sports. Provincial Water Quality Objectives for body contact recreational activities require that the waters be free from pathogenic bacteria, fungi, or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections.

Inadequately treated sewage and fecal material are primary sources of disease-causing organisms. Wastes from combined sewer overflows and sewage treatment plant bypasses can contribute significant numbers of microbiological agents to water bodies. Storm water runoff from residential areas may also be highly contaminated with animal fecal material. Microbiological studies concentrate on the coliform group of bacteria as indicators of pollution from sewage. A portion of this group, the fecal coliforms, characteristically occur in large numbers in the colon and feces of warm-blooded animals. The fecal coliform measurement has been preferred as an indication of fecal contamination. Since Pseudomonas aeruginosa is only found in the feces of man, the presence of this pathogen specifies contamination from human fecal waste.

TABLE 6

Mean Concentrations (geometric) of microbiological indicators in Niagara River Surface Waters, 1980-82

	STATION/RANGE	TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI	PSEUDOMONAS AURUGINOSA	HETEROTROPHIC BACTERIA
1980	NI 37.7	71	4	8	3	4583
	NI 26.7	107	4	14	2	4106
	NI 19.3	607	14	27	4	17881
	NI 23.3	378	12	28	4	11818
	NI 35.2	108	4	15	3	4042
	NI 20.5	139	3	15	2	4237
	NI 31.0	190	7	19	4	6637
	NI 6.8	769	21	26	6	11541
	NI 1.3	855	17	27	6	13410
	NI 3.7	782	18	30	6	13119
1981	NI 37.7	38	4	11	3	3627
	NI 19.3	788	14	26	4	18265
	NI 20.5	122	3	12	3	5764
	NI 1.3	976	26	16	4	21480
1982	NI 37.7	59	4	6	2	NA
	NI 32.5	107	4	5	2	NA
	NI 19.3	240	10	8	2	NA
	NI 20.5	150	3	5	2	NA
	20	1042	89	38	3	NA
	22	579	10	6	3	NA
	32	1072	18	14	3	NA
	33	775	11	14	4	NA
	34	578	15	9	3	NA
	35	159	3	6	<2	NA
	NI 1.3	767	44	16	2	NA
Provincial Water Quality Objectives		1000	100			

All units = organisms/100 mL

An additional indicator of fecal contamination is the fecal streptococci group of bacteria. Not all species are associated with fecal contamination, but those that are may provide a distinct advantage over the coliform group of bacteria. *Streptococcus bovis* and *S. equinus* have shorter survival times in fresh water; this provides information on how recent the fecal contamination is . Both the fecal coliform and fecal streptococci groups of bacteria are considered to be non-pathogens; however, their presence in surface water serves as an indicator of the possible presence of pathogenic organisms.

While current Provincial Water Quality Objectives are based on levels of fecal coliforms, certain members of this group may not be of strict fecal origin. *Escherichia coli*, a member of the fecal coliform group, is strictly of fecal origin. *E. coli* are restricted to the gut of warm-blooded animals. This type of specificity allows for further fecal source characterization.

The total coliform group of bacteria contains some strains that are more common in the environment than in fecal material; tend to survive longer in water; and are more resistant to disinfection (chlorination) than either the fecal coliforms or the commonly occurring bacterial pathogens. The total coliform group is considered a useful indicator of water quality impairment.

The presence of high densities of heterotrophic bacteria are indicative of increased organic enrichment. Greater densities of heterotrophic bacteria are found in lakes and rivers with a higher trophic status.

From 1980 to 1982 samples were analyzed for total coliforms, fecal coliforms, fecal Streptococcus, Pseudomonas aeruginosa and heterotrophic bacteria.

The Buffalo Harbour and river mouth area contributed higher levels of total coliforms to the Niagara River than Lake Erie (as evidenced by an increase in geometric mean densities at the eastern end of Range NI 37.7 (Figure 4)). Although some individual samples contained up to 15,000 organisms/100 mL, the geometric means rarely exceeded the Water Quality Objective of 1000 org./100 mL. A cross-channel gradient in total coliform bacteria was also evident during 1980 in the Tonawanda Channel, with geometric mean densities for stations adjacent to the easterly shore at NI 31.0 (1157 org/100 mL), NI 23.3 (2425 org/100 mL) and NI 19.3 (3288 org/100 mL) exceeding the Objective. In 1981, the geometric mean of 3736 org/100 mL at NI 19.3, adjacent to the U.S. mainland shore exceeded the Objective and in 1982, Stations 20 and 32 on the Tonawanda Channel had geometric means (1042 org/100 mL and 1072 org/100 mL) in excess of the Objective as well.

During 1980, samples taken along the length of the Tonawanda channel (NI 31.0, 23.3 & 19.3) indicated a trend of increasing total coliform densities with greater distance downstream. This trend could not be confirmed during 1981, since only one transect (NI 19.3) in the channel was sampled; however, the same trend was observed in 1982 (Stns. 34, 33 and 32 and Stns. 22 and 20). Kuntz & Chan (1982) also reported large increases total coliform densities in cross-stream and downstream directions in the Tonawanda Channel during 1975 and 1979.

The strong cross-channel gradient of total coliforms of the magnitude evident in the Tonawanda Channel was not as apparent in the Chippawa Channel (Figure 4). Furthermore, the Objective for total coliforms was not exceeded in the Chippawa Channel, with geometric mean densities for individual stations ranging from 80 - 226 org/100 mL during 1980, 68 - 390 org/100 mL during 1981, and 96 - 223 org/100 mL in 1982.

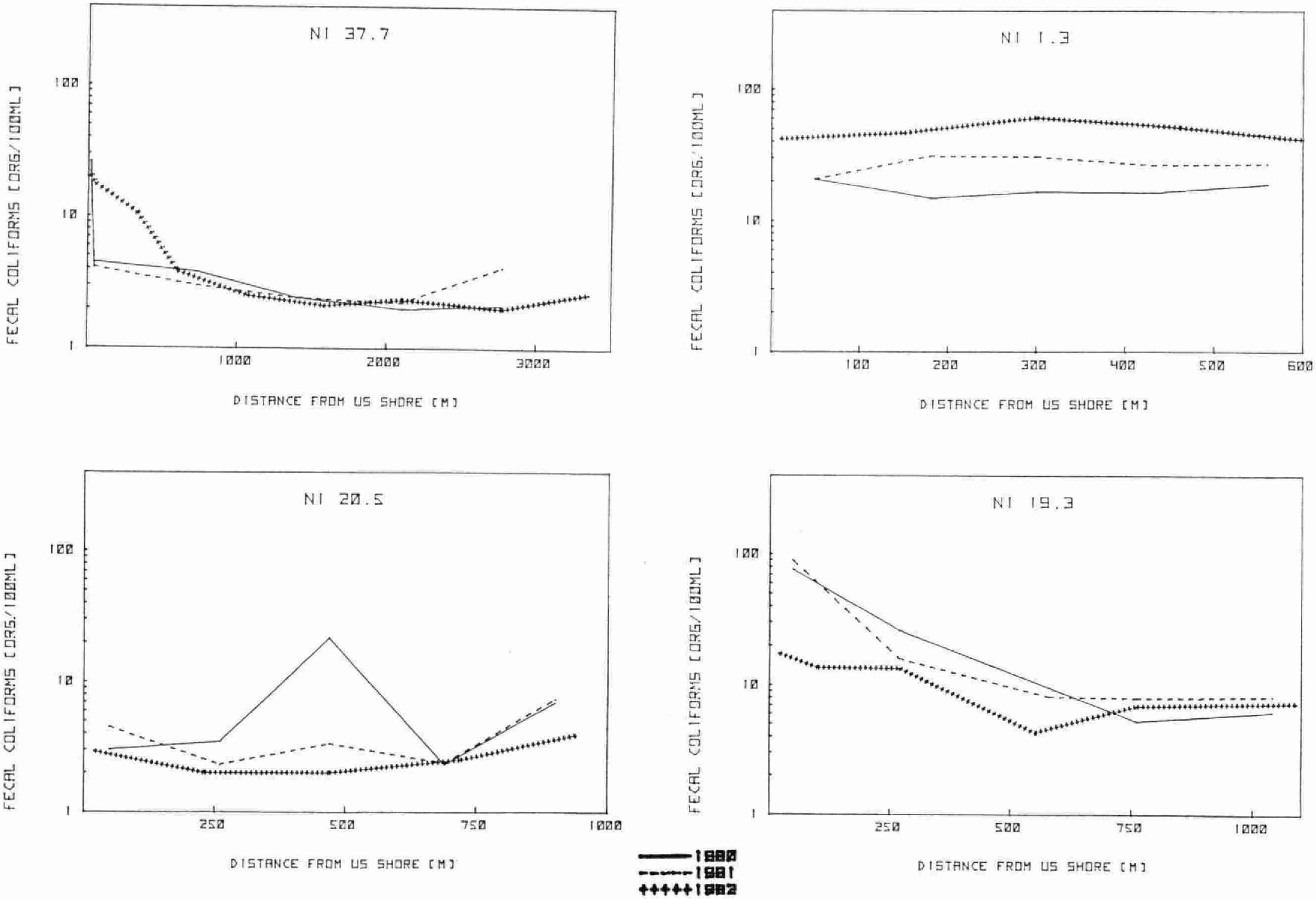

FIGURE 4: Total Coliform levels in the Niagara River, 1980-1982

While a cross-channel bacterial density gradient was not apparent for the lower river during the survey years, mean total coliform bacteria densities for individual stations ranging from <100 to 8900 org/100 mL were generally higher than densities in the upper river (688 - 913 org/100 mL for 1980; 766 - 1326 org/100 mL during 1981 and 623 - 967 org/100 mL in 1982), indicating the possible presence of sources below the Falls. The water quality Objective was exceeded adjacent to the Canadian shore along Range NI 1.3 during 1981. Since this area has very little downstream water movement (IJC, 1951), any nearby source, such as storm water overflow, could produce a marked effect.

The spatial distributions of fecal coliform bacteria were similar to those of total coliform bacteria. Elevated levels were observed along NI 37.7 in the Buffalo River mouth and Harbour area and along NI 19.3 near the mainland shore of the Tonawanda Channel as well as along the entirety of Ni 1.3 in the lower river (Figure 5). Elevated levels of *Pseudomonas* and fecal *Streptococcus* were also observed at these locations and are probably indicative of nearby sanitary pollution. Similar spatial trends were evident for heterotrophic bacteria.

D. **Phenols**:

During 1980 and 1981, detections of total phenolics from each of the four areas sampled in the river ranged from 0 - 22%, and were in excess of the Provincial Water Quality Objective (PWQO) of 1 ug/L in 3% or less of the samples (Table 7). Concentrations above detection ranged from 1 to 2 ug/L. This represents a substantial reduction since 1971, when up to 100% of samples from the Niagara River exceeded the Objective and concentrations up to 80 ug/L were encountered (Kauss, 1983).

Analytical results for total phenolics during 1982 show detections ranging from 46 - 55% and Objective exceedences ranging from 23 - 34%. The higher frequencies of detection and exceedences in 1982 is a result of a change in the method of reporting of analytical results and not due to changes in the methods of analysis. For example, reported concentrations for the entire river ranged from 0.8 to 3.6 ug/L, with 14% of these occurring in the 1.2 - 1.4 ug/L range and 12% between 1.6 and 3.6 ug/L.

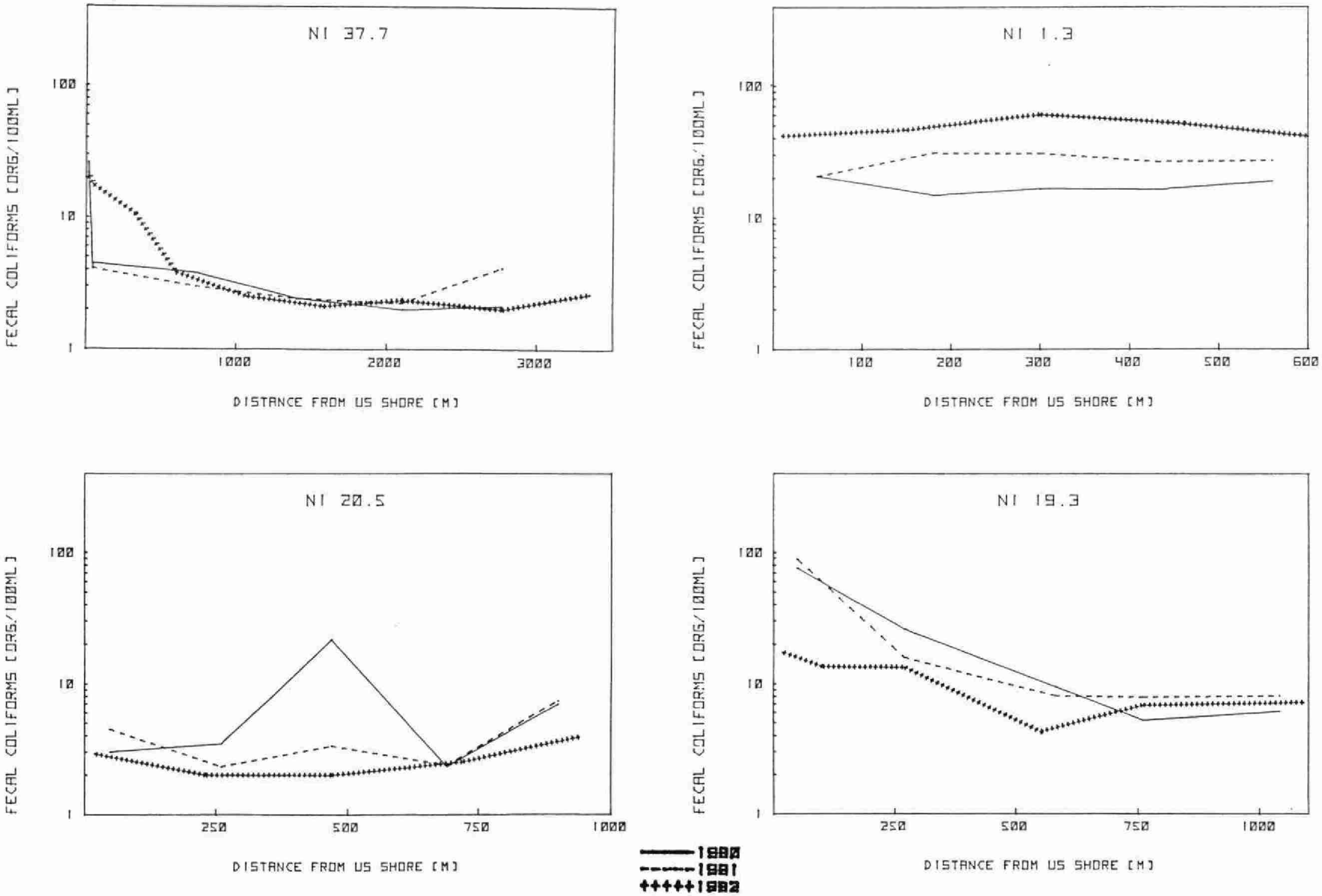

FIGURE 5: Fecal Coliform levels in the Niagara River, 1980-1982

TABLE 7

Number of samples, % detected and % exceeding the PWQO for total phenolics in Niagara River Surface Water - 1980-1982

	Upper River NI 37.7			Chippawa Channel NI 20.5			Tonawanda Channel NI 19.3			Lower River NI 1.3		
	n	% d	%>c	n	% d	%>c	n	% d	%>c	n	% d	%>c
1980	78	1	1	60	8	0	60	10	2	60	0	0
1981	72	18	0	60	12	0	60	22	3	44	20	0
1982	107	47	23	60	50	27	72	58	28	58	46	34

n = number of samples
%d = percent detected
%>c = percent exceeding PWQO (1 ug/L)

E. Inorganic Trace Contaminants

Tables 8-10 provide mean and standard error data on inorganic trace contaminant concentrations for 1980 to 1982.

Data for the percentages of trace metal detections and PWQO violations for 1980 to 1982 are presented in Table 12. A comparison of mean concentrations of trace metals in Niagara River surface waters appears in Table 11.

Over the three-year period from 1980 to 1982, levels in excess of the Objectives were consistently observed for cadmium (0 - 40% of samples), copper (7 - 54%), iron (0 - 32%) and silver (8 - 71%). Generally, a lower percentage of samples in excess of the Objectives were observed for mercury (0 - 23%) and zinc (0 - 4%).

A greater percentage of samples exceeded the PWQO's for cadmium and copper in 1981 and 1982 as opposed to 1980. The increases were not restricted to a particular survey range; instead, there appeared to be a general elevation in exceedences throughout the entire river. These increases were maintained during 1982. In addition, copper Objective exceedences in the Chippawa Channel and lower river were higher in 1982 than in 1981.

While the percentage of sample detections for iron remained high during 1981, the percentage of samples exceeding the Water Quality Objectives was lower than in 1980. This is in contrast to a significant increasing trend between 1975 and 1979 reported by Kuntz and Chan (1982) for the upper Niagara River. In 1982, with the exception of no exceedences in the Tonawanda Channel, no major change in the number of samples in which iron exceeded Water Quality Objectives was observed over 1981 samples.

TABLE 8

Mean Concentration ± SE of Inorganics (ug/L) in Niagara River Surface Waters, 1980

1980	Tonawanda Channel NI 19.3	Chippawa Channel NI 20.5	Lower River NI 1.3
aluminium	448 ± 122	246 ± 56	244 ± 44
arsenic	0.84 ± 0.12	0.55 ± 0.09	0.50 ± 0.09
cadmium	0.03 ± 0.02	0.03 ± 0.02	0.03 ± 0.01
chromium	2.0 ± 0.45	0.89 ± 0.24	0.33 ± 0.23
copper	2.4 ± 0.3	3.6 ± 1.0	1.5 ± 0.6
cyanide (avail)	<0.01	<0.01	<0.01
iron	471 ± 96	216 ± 39	163 ± 24
lead	0.17 ± 0.2	0.14 ± 0.1	0.20 ± 0.20
mercury (filt)	0.11 ± 0.02	0.05 ± 0.01	0.10 ± 0.02
nickel	0.6 ± 0.2	0 ± 0.07	0.6 ± 0.3
zinc	5.8 ± 1.2	2.3 ± 0.4	5.1 ± 1.8

Notes:

(1) Mean and Standard error calculated assuming that samples less than detection limit were zero.

(2) For parameters which were not present in any samples above the detection limit (mean concentration = 0) a calculated standard error was derived by multiplying the detection limit by two.

TABLE 9

Mean Concentration ± SE of Inorganics (ug/L) in Niagara River Surface Waters, 1981

1981	Upper River NI 37.7	Tonawanda Channel NI 19.3	Chippawa Channel NI 20.5	Lower River NI 1.3
aluminum	90 ± 61	152 ± 18	90 ± 9	147 ± 9
arsenic	<1	<1	<1	<1
cadmium	0.18 ± 0.05	0.30± 0.14	0.16 ± 0.50	0.18 ± 0.04
chromium	4.1 ± 1.7	2.6 ± 0.2	2.6 ± 0.4	3.2 ± 0.2
copper	8.4 ± 2.3	5.6 ± 0.5	4.4 ± 0.5	6.6 ± 1.2
cyanide	<0.010	<0.010	<0.010	<0.010
iron	71 0 ± 9.0	222 ± 57	108 ± 19	136 ± 6
lead	1.83 ± 0.43	1.90 ± 0.37	1.68 ± 0.32	3 ± 0.4
mercury (filt)	NA	0.07 ± 0.02	0.09 ± 0.02	0.12 ± 0.004
nickel	2.4 ± 0.4	2.6 ± 0.5	2.1 ± 0.2	3.2 ± 0.3
selenium	<0.001	<0.001	<0.001	NA
zinc	4.4 ± 0.8	7.2 ± 2.7	4.8 ± 1.4	6.5 ± 0.9

Notes:

(1) Mean and Standard error calculated assuming that samples less than detection limit were zero.

(2) For parameters which were not present in any samples above the detection limit (mean concentration = 0) a calculated standard error was derived by multiplying the detection limit by two.

TABLE 10

Mean Concentration ± SE of Inorganics (ug/L) in Niagara River Surface Waters, 1982

	Upper River NI 37.7	Tonawanda Channel NI 19.3	Chippawa Channel NI 20.5	Lower River NI 1.3
aluminum	78 ± 7	96 ± 10	180 ± 50	100 ± 8
arsenic	0 ± 2	0 ± 2	0 ± 2	0 ± 2
cadmium	0.09 ± 0.02	0.19 ± 0.04	0.09 ± 0.03	0.2 ± 0.04
chromium	4.8 ± 1.4	5.2 ± 1.2	7.4 ± 2.3	3.3 ± 1.0
copper	5.1 ± 0.3	5.2 ± 0.6	6.6 ± 1.4	7.1 ± 0.9
iron	93 ± 14	135 ± 16	238 ± 80	157 ± 51
lead	0.9 ± 6	0 ± 6	0 ± 6	0 ± 6
mercury	0 ± 0.16	0 ± 0.16	0 ± 0.16	0 ± 0.16
nickel	0.8 ± 0.1	1.5 ± 1.1	1.6 ± 0.3	1.5 ± 0.4
zinc	2.1 ± 0.3	11.5 ± 4.7	2.4 ± 0.5	3.8 ± 0.6

Notes:

(1) Mean and Standard error calculated assuming that samples less than detection limit were zero.

(2) For parameters which were not present in any samples above the detection limit (mean concentration = 0) a calculated standard error was derived by multiplying the detection limit by two.

TABLE 11

Comparison of Mean Inorganic Contaminant Concentrations (ug/L) in Niagara River Surface Waters - 1980 to 1982

	Upper River NI 37.7		Tonawanda Channel NI 19.3			Chippawa Channel NI 20.5			Lower River NI 1.3		
	81	82	80	81	82	80	81	82	80	81	82
aluminium	90	78	448	152	96	246	90	180	244	147	100
arsenic	0	0	0.84	0	0	0.55	0	0	0.50	0	0
cadmium	0.18	0.09	0.03	0.30	0.19	0.03	0.16	0.09	0.03	0.18	0.20
chromium	4.1	4.8	2.0	2.6	5.2	0.89	2.6	7.4	0.33	3.2	3.3
copper	8.4	5.1	2.4	5.6	5.2	3.6	4.4	6.6	1.5	6.6	7.1
iron	71	93	471	222	135	216	108	238	163	136	157
lead	1.83	0.9	0.17	1.90	0	0.14	1.68	0	0.2	3	0
mercury (filt.)	NA	N/A	0.11	0.07	N/A	0.05	0.09	N/A	0.10	0.12	N/A
nickel	2.4	0.8	0.6	2.6	1.5	0	2.1	1.6	0.6	3.2	1.5
zinc	4.4	2.1	5.8	7.2	11.5	2.3	4.8	2.4	5.1	6.5	3.8

TABLE 12

% of samples exceeding the PWQO in Niagara River Surface Waters - 1980-1982

	Upper River NI 37.7			Chippawa NI 20.5			Tonawanda NI 19.3			Lower River NI 1.4			PWQO (ug/L)
	80	81	82	80	81	82	80	81	82	80	81	82	
arsenic	-	0	0	0	0	0	0	0	0	0	0	0	100
cadmium	-	28	18	10	31	17	7	29	33	0	40	38	0.2
chromium	-	0	0	0	0	0	0	0	0	0	0	0	100
copper	-	48	44	7	34	50	7	45	25	7	38	54	5
iron	-	6	5	21	4	8	32	23	0	14	5	4	300
lead	-	0	0	0	0	0	0	0	0	0	0	0	25
mercury (filt.)	-	14	-	4	0	-	23	0	-	13	0	-	0.2
nickel	-	0	0	0	0	0	0	0	0	0	0	0	25
selenium	-	0	0	-	0	0	-	0	0	-	-	0	100
silver	-	71	12	-	-	17	-	57	8	-	-	17	0.1
zinc	-	2	0	0	2	0	0	0	8	0	2	4	30

Arsenic, free cyanide, chromium, lead, nickel and selenium were never detected at levels exceeding the Water Quality Objectives. However, arsenic was detected in up to 64% of samples taken throughout the river during 1980, yet only found in 2% of samples taken from the mouth of the river during 1981. It should be mentioned that the analytical detection limit for free cyanide of 10 ug/L is higher than the Water Quality Objective of 5 ug/L and therefore some levels exceeding the Objective may have been undetected. This also applies to silver, with an analytical detection limit of 0.5 ug/L.

Filtered mercury was detected at levels exceeding the PWQO of 0.2 ug/L in both the Tonawanda Channel and Chippawa Channel during 1980 but not in 1981. Mercury levels in excess of the Objective along the headrange (Ni 37.7) were observed in both 1981 and 1982.

The PWQO for zinc (30 ug/L) was exceeded during 1981 and 1982; but never in more than 4% of the samples taken.

F. **Organic Trace Contaminants**:

Analyses for PCBs and organochlorine pesticides during 1980, 1981 and 1982 indicated that the majority of samples contained concentrations below the Water Quality Objectives. Summaries of the analytical results are presented in Tables 13, 14 and 15.

Levels of PCBs exceeded the Provincial Objective of 0.001 ug/L in 9% of samples from the Tonawanda Channel (range: 0.020 - 0.040 ug/L) and in 7% from Chippawa Channel (range: 0.020 - 0.080 ug/L) during 1980. During 1981, PCBs were only detected in water samples from the Tonawanda Channel, with 5% exceeding Provincial Objectives (range: 0.020 - 0.045 ug/L). In 1982, PCBs were in excess of the PWQO in the Tonawanda Channel at the mouth of the Little River (Stn. 20) and at the headrange in only about 8% and 2%, respectively, of the samples (range: 0.020 - 0.025 ug/L). No PCBs were detected in the lower river during any survey year. However, the percentage of samples exceeding the Objective for PCBs throughout the river may be underestimated, since the routine analytical detection limit of (0.020 ug/L) exceeds the Water Quality Objective.

TABLE 13

PCBs and organochlorine pesticides in Niagara River Surface Waters, 1980

	Tonawanda Channel NI 19.3			Chippawa Channel NI 20.5			LOWER RIVER NI 1.3			PWQO (ug/L)
	n	% d	%>c	n	% d	%>c	n	% d	%>c	
PCBs	44	9	9	42	7	7	60	0	0	0.001
aldrin	44	0	0	42	0	0	50	0	4	0.001
dieldrin	44	0		42	7		50	4		
α-BHC	44	68	-	42	64	-	55	78	-	-
β-BHC	44	11	-	42	10	-	55	9	-	-
γ-BHC	44	16	0	42	17	0	55	18	0	0.01
α-Chlordane	44	7	0	42	0	0	55	4	0	0.06
γ-Chlordane	44	4		39	8		55	5		
o'p'-DDT	44	0	0	42	0	5	55	2	2	0.003
p'p'-DDT	44	0		42	5		55	0		
p'p'-DDD	39	0		41	0		55	2		
p'p'-DDE	44	2		42	0		60	2		
endrin	44	4	2	41	5	0	55	2	2	0.002
heptachlor	44	0	2	42	0	7	55	0	7	0.001
heptachlor epoxide	44	7		42	21		55	9		
HCB	44	4	-	42	0	-	55	0	-	-
mirex	44	0	0	42	0	0	55	0	0	0.001
endosulphan sulphate	44	0	0	42	0	0	55	0	0	0.003
endosulphan I	44	0		42	2		55	2		
endosulphan II	44	0		42	0		55	2		

n - number of samples
% d - percentage of samples detected
%>c - percentage of samples greater than criteria (PWQO)

TABLE 14

PCBs and Organochlorine Pesticides in the Niagara River Surface Waters, 1981

STATION	Upper River NI 37.7			Tonawanda Channel NI 19.3			Chippawa Channel NI 20.5			Lower River NI 1.3			PWQO (ug/L)
	n	%d	%>c	n	%d	%>c	n	%d	%>c	n	%d	%>c	
PCBs	72	0	0	60	5	5	60	0	0	60	0	0	0.001
aldrin	72	0	1	60	0	2	60	0	0	60	0	0	0.001
dieldrin	72	1		60	2		60	0		60	0		
α-BHC	72	58	-	60	75	-	60	75	-	60	73	-	-
β-BHC	72	1	-	60	5	-	60	0	-	60	0	-	-
γ-BHC	72	10	0	60	15	0	60	5	0	60	27	0	0.01
α-Chlordane	72	0	0	60	2	0	60	0	0	60	0	0	0.06
γ-Chlordane	72	0		60	0		60	0		60	0		
o'p'-DDT	72	0	0	60	0	2	60	0	0	60	0	0	0.003
p'p'-DDT	72	0		60	2		60	0		60	0		
p'p'-DDD	72	0		60	0		60	0		60	0		
p'p'-DDE	72	1		60	2		60	0		60	3		
endrin	72	0	0	60	0	0	60	0	0	60	0	0	0.002
heptachlor	72	0	0	60	0	0	60	0	0	60	0	0	0.001
heptachlor epoxide	72	0		60	2		60	0		60	0		
HCB	72	1	-	60	12	-	60	0	-	60	3	-	-
mirex	72	0	0	60	0	0	60	0	0	60	0	0	0.001
endosulphan sulphate	72	0	0	60	0	0	60	0	0	60	0	0	0.003
endosulphan I	72	1		60	0		60	0		60	0		
endosulphan II	72	1		60	0		60	0		60	0		
oxchlordane	72	0	-	60	0	-	60	0	-	60	0	-	-
methoxyclor	72	0	0	60	0	0	60	0	0	60	0	0	0.04

n - number of samples
% d - percentage of samples detected
%>c - percentage of samples greater than criteria (PWQO)

TABLE 15

PCBs and trace organics in the Niagara River, 1982

STATION	5			7			34			33			32			22			20			9			35			15			4			PWQO (ug/L)
	n	% d	%>c	n	% d	%>c	n	% d	%>c	n	% d	%>c	n	% d	%>c	n	% d	%>c	n	% d	%>c	n	% d	%>c	n	% d	%>c	n	% d	%>c	n	% d	%>c	
PCBs	39	2	2	24	0	0	11	0	0	12	0	0	11	0	0	11	0	0	12	0	0	2	0	0	11	0	0	12	0	0	24	0	0	0.001
aldrin	39	0	0	24	0	0	11	0	0	12	0	0	11	9	9	12	0	0	12	8	8	2	0	0	11	0	9	12	0	0	24	0	0	0.001
dieldrin	39	0		24	0		11	0		12	0		11	0		12	0		12	0		2	0		11	9		11	0		24	0		
α-BHC	39	82	-	24	92	-	11	82	-	12	83	-	11	73	-	12	83	-	12	92	-	2	92	-	11	91	-	12	92	-	24	83	-	-
β-BHC	39	8	-	24	0	-	11	9	-	12	0	-	11	9	-	12	8	-	12	33	-	2	25	-	10	0	-	12	0	-	23	4	-	-
γ-BHC	39	31	2	24	25	0	11	36	0	12	17	0	11	36	0	12	42	0	12	67	8	2	50	0	11	45	0	12	33	0	23	35	0	0.001
α-Chlordane	39	0	0	24	0	0	11	0	0	12	8	0	11	0	0	12	0	0	12	8	0	2	0	0	11	0	0	12	0	0	23	0	0	0.06
γ-Chlordane	39	0		24	0		11	0		12	0		11	0		12	0		12	0		2	0		11	0		12	0		23	0		
o'p'-DDT	39	0	0	24	0	0	11	0	0	12	0	0	11	0	0	12	0	0	12	0	0	2	0	0	11	0	0	12	0	0	23	0	0	0.003
p'p'-DDT	39	0		24	0		11	0		12	0		11	0		12	0		12	0		2	0		11	0		12	0		23	0		
p'p'-DDD	39	0		24	0		10	0		12	0		11	0		12	0		12	0		2	0		11	0		12	0		23	0		
p'p'-DDE	39	0		24	14		11	0		12	0		11	0		12	0		12	0		2	0		11	0		12	0		23	0		
endrin	39	0	0	24	0	0	11	0	0	12	0	0	11	0	0	12	0	0	12	0	0	2	0	0	11	0	0	12	0	0	23	0	0	0.002
heptachlor	39	0	0	24	0	4	11	0	0	12	0	0	11	0	0	12	0	0	12	0	0	2	0	0	11	0	0	12	0	0	24	0	0	0.001
heptachlor epoxide	39	2		24	4		11	9		12	0		11	0		12	0		12	8		2	0		11	9		12	0		24	4		
HCB	39	2	-	24	0	-	11	9	-	12	0	-	11	9	-	12	8	-	12	0	-	2	9	-	11	0	-	12	0	-	24	0	-	-
mirex	39	0	0	24	4	4	11	0	0	12	0	0	11	0	0	12	0	0	12	0	0	2	0	0	11	0	0	12	0	0	24	0	0	0.001
endosulphan sulphate	39	0	0	24	0	0	11	0	0	12	0	0	11	0	0	12	0	0	12	0	0	2	0	0	11	0	0	12	0	0	24	0	0	0.003
endosulphan I	39	0		24	0		11	0		12	0		11	0		12	0		12	0		2	0		11	0		12	0		23	0		
endosulphan II	39	0		24	0		11	0		12	0		11	0		12	0		12	0		2	0		11	0		12	0		24	0		
oxchlordane	39	0	-	24	0	-	11	0	-	12	0	-	11	0	-	12	0	-	12	0	-	2	0	-	11	0	-	12	0	-	24	0	-	-
mehoxychlor	39	0	0	24	0	0	11	0	0	12	0	0	11	0	0	12	0	0	12	0	0	2	0	0	11	0	0	12	0	0	24	0	0	0.04

n - number of samples
%d - percentage of samples detected
%>c - percentage of samples greater than criteria (PWQO)

While there is currently no Water Quality Objective for alpha-BHC, this hexachlorocyclohexane isomer was detected (throughout the river) in 64% - 78% of water samples collected during 1980, in 58% - 75% collected during 1981 and in 73% - 92% collected in 1982. Beta-BHC was also detected in up to 11%, 5% and 33% of water samples collected during 1980, 1981 and 1982 respectively. Gamma-BHC (Lindane) was detected throughout the river during 1980 (14 - 18%), 1981 (5 - 27%) and 1982 (17 - 67%). In 1982, Lindane concentrations exceeded the Water Quality Objective of 0.01 ug/L, at the headrange (2%) and in the Tonawanda Channel-Little River area (8%).

Endrin and heptachlor epoxide were both detected throughout the Niagara River during 1980 in up to 5% and 21% of samples, respectively. Levels exceeding the Objectives were found in from 2% to 7% samples. During 1981 and 1982, endrin was never detected. Heptachlor epoxide was only found in one sample from the Tonawanda Channel in 1981 but again throughout the river in 1982, with all levels below the Water Quality Objective (0.001 ug/L).

Dieldrin, the degradation product of aldrin, exceeded the Objective of 0.001 ug/L in 4% of samples taken from the lower river and in 7% of samples from the Chippawa Channel during 1980. During 1981 and 1982, dieldrin was only detected in the Tonawanda Channel with, 2% and 3% of the respective samples exceeding the Objective.

Isomers of Chlordane (alpha and gamma) were detected in up to 8% of samples from the upper and lower Niagara River during 1980; however, the sum of the isomers did not exceed the Provincial Objective of 0.06 ug/L (the Great Lakes Water Quality Agreement Objective is 0.01 ug/L). During the following years, α-Chlordane was only detected in the Tonawanda Channel during 1981 in 2% of the samples, and in 1982 in 8% of samples from the Pettit Flume (Stn. 33) and Little River mouth (Stn. 20) areas. Levels were below the Objective. Chlordane, a restricted substance in Canada since 1977, is currently limited to licensed application in greenhouses and nurseries and in dwellings for the control of cockroaches and termites.

Metabolites of DDT were found in a few samples throughout the river during both 1980 and 1981 survey years; however, no particular pattern of detection was apparent. p'p' DDE was found in 14% of samples in the upper river (NI 32.5) during 1982. This range is immediately downstream of the Buffalo Sewer Authority plant discharge and the outlet of the Black Rock Canal.

While concentrations of organic trace contaminants in water were generally below the Water Quality Objectives, previous analyses of suspended sediment, bottom sediment and fish are indicative of their presence in other media (COA 1980, 1981). PCBs and organochlorine pesticides are only sparingly soluble in water and adsorb onto bottom and/or suspended sediments. Concentrations of PCBs in Niagara River suspended sediments exceeded the MOE dredge spoil criterion of 50 ppb in 100% of samples taken during 1980 (COA 1981).

Table 16 lists an extensive number of toxic organic compounds which were tested in 1982. Of the 52 compounds, only 6 were identified in Niagara River waters, with ranges just above the analytical detection limits. Dichloromethane ranged in concentration from 11 ug/L to 60 ug/L and was detected in both the Tonawanda Channel and the upper River (NI 32.5) stations. Toluene, ethyl-benzene, dichloroethane, 1,2-dichloropropane, 1,1,2-trichloroethylene and the highest detected concentrations of dichloromethane were found in the upper river and the upper reach of the Tonawanda Channel, while very few measurable concentrations were found downstream.

VI CONCLUSIONS

1. For the survey years 1980, 1981 and 1982, the results indicated that there were cross-channel gradients of nutrients and microbiological parameters, with the highest concentrations observed in the Buffalo River mouth area and along the mainland shore of the Tonawanda Channel. These areas of nutrient enrichment and bacterial contamination are related to waste discharges from areas of urban and industrial development.

2. Provincial Water Quality Objectives were exceeded on occasion for total coliforms in areas along the Tonawanda Channel, Buffalo River mouth and Harbour area and in the lower river during all three survey years.

3. Over the three year period from 1980 to 1982, levels of copper, iron and silver were frequently found in excess of the Objectives. Arsenic, cyanide, chromium, lead, nickel and selenium were never detected at levels exceeding the Objectives.

4. PCB and organochlorine pesticide analyses for all years indicate that the majority of these contaminants were below the Water Quality Objectives. PCBs exceeded the Objectives, in the Upper Niagara River only, in less than 10% of the samples from the Tonawanda and Chippawa Channels and at the headrange.

   Levels of γ-BHC, heptachlor epoxide, endrin and dieldrin occasionally (<10%) exceeded Provincial Water Quality Objectives, primarily in the Tonawanda Channel, although detections of organochlorine pesticides were observed throughout the river. Of the fifty-two additional compounds investigated in 1982, only six were identified in Niagara River water (1-7% of samples), with concentrations just above the analytical detection limits.

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